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ABSTRACT

This training guide, prepared to assist administrators and instructors in organizing courses and developing course content in training electronics mechanics, contains 14 major course units covering 6 hours per day, 5 days per week for 50 weeks or 1,500 hours of shop and classroom instruction. The units included are: (1) Mathematics, (2) Direct Current Electricity, (3) Electronic Shop Tools, (4) Magnetics, (5) Communications, Writing, (6) Alternating Current Electricity, (7) Electronic Devices, (8) Power Supply, (9) Sketching and Blueprint Reading, (10) Amplifiers, (11) Oscillators, (12) Waveshaping, (13) Electronic Controls, and (14) Communications, Transmitters and Receivers. Lists of suggested machines, tools, equipment, supplies, textbooks, films, and a floor plan of the training facility are appended. (GR)

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electronics mechanic, entry

a suggested guide for a training course

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OE-87040

ELECTRONICS MECHANIC, ENTRY

(D.O.T. Occupational Code 828.281)

A Suggested Guide for a Training Course

ED037578

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF EDUCATION

ROBERT H. FINCH, *Secretary*
JAMES E. ALLEN, JR., *Assistant Secretary and Commissioner of Education*

BUREAU OF ADULT, VOCATIONAL, AND LIBRARY PROGRAMS
Grant Venn, *Associate Commissioner*

Manpower Development and Training Program

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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Foreword

The rapid growth and development in the practical applications of electronics have created a demand for persons qualified to install and service electronic apparatus and equipment. The supply of qualified electronics mechanics has not been equal to the demand and the need for expanded training resources has become evident. This guide will assist administrators and instructors in organizing courses and developing course content. It was prepared for the Division of Manpower Development and Training, under the supervision of its director, Howard A. Matthews. Recognition is given to Maurice W. Roney, Professor of Industrial Education, Oklahoma State University, for supervising the development of the content; to L. Carl Love, Oregon State University, for assisting as consultant during the preparation of this guide; and to Richard W. Tinnell, Instructor of Electronics, Technical Institute, Oklahoma State University, for gathering the technical material for this guide.

This guide contains 14 major units covering 1,500 hours of shop and classroom instruction. The sequence of instruction material and the hours assigned are suggestions; therefore, both time and content may be adjusted to meet local needs. Suggested lists of machines, tools, equipment, supplies, textbooks, and films, and a floor plan of the training facility have been included to assist school administrators and instructors in organizing the course. The assistance of local advisory groups should be sought when selecting equipment. Modification of the suggested shop training facility should follow advisory committee recommendations.

GRANT VENN
Associate Commissioner for
Adult, Vocational, and Library Programs.

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Background

Purpose of the Guide

This training guide has been prepared to assist in planning and developing a course for training electronics mechanics. It has been organized to be of maximum value to school administration personnel who may not be specialists in the occupation.

The suggestions outlined in the training guide are not meant to delineate instruction in every detail. Supplemental material can be found in the suggested lists of textbooks, references, and films. The sequence of presentation as well as the final selection of topics for special emphasis should be determined by the instructor and will vary, depending on the needs and background of the trainee group.

Although this training guide has been developed primarily for use in the Manpower Development and Training Program, it includes instructional material that goes beyond the development of manipulative exercises to impart simple skills. Some of the related material included in the course outline has been added to enable the trainee to progress beyond the entry level job.

Job description

The occupation of electronics mechanic normally includes jobs which require a knowledge of electrical or electronic circuits and the operation of electrical or electronic equipment. These workers may be required to test, repair, and adjust direction-finding, computing, radar, television, and related electronics equipment—including timers, transmitters, receivers, indicators, antenna systems, and servomechanisms. They may be called upon to determine the characteristics of circuits, using a signal generator, oscilloscope, and other electronic testing devices to locate defects. They may also be required to replace defective parts and to realign various stages.

A typical routine task for the electronics mechanic would be to analyze the electrical system of an industrial device by checking components and circuits (using the manufacturer's specifications) and to make corrections or adjustments that will remedy faulty or inefficient operation.

Electronics mechanics are employed in virtually every industry involved in the manufacture of electrical components or apparatus. Such mechanics may also be employed in nonelectrical manufacturing where automatic or semiautomatic control of a manufacturing process is used.

In the decade between 1950 and 1960, the demand for workers in the electronics industries has increased by almost 700 percent. The supply of such workers has lagged behind the demand by a considerable amount. It is expected that this situation is likely to continue for some time. Consequently, trained mechanics in this field should experience little difficulty in obtaining employment.

Wages which start near $4,500 per year can increase to around $8,000 per year after gaining the necessary experience. Electronics mechanics can advance to positions as foremen and supervisors. Those who obtain additional training and education may move laterally into other areas such as production supervision, quality control, or developmental laboratory work.

Length of Course and Course Units

The training course, as outlined, covers a period of 50 weeks and includes a total of 1,500 hours of class instruction and shop practice. The training is intended to progress at a rate of six hours per day, five days per week.

Unit	*Title*	*Suggested class hours*	*Suggested shop hours*
I.	Mathematics	135	0
II.	Direct Current Electricity	60	85
III.	Electronic Shop Tools	22	59
IV.	Magnetics	40	20
V.	Communications, Writing	30	0
VI.	Alternating Current Electricity	95	130
VII.	Electronic Devices	45	60
VIII.	Power Supply	30	50
IX.	Sketching and Blueprint Reading	17	60
X.	Amplifiers	55	90
XI.	Oscillators	40	65
XII.	Waveshaping	41	66
XIII.	Electronic Controls	45	65
XIV.	Communications, Transmitters, and Receivers	45	50
	Subtotal	700	800
			700
	Total		1,500

Qualifications of Trainees

A high school diploma, or its equivalent, is desirable for electronics mechanic occupations, but not absolutely necessary. Workers in this field should, in general, be at least in average physical condition and health. Physical handicaps do not necessarily disqualify persons for employment in this field. However, because of the wide use of color for identification of electrical wire and components, color blindness may be a serious handicap.

The trainees should have the ability to visualize the spatial relationships involved in a system and the interrelationship of peripheral equipment and subassemblies. They must have good motor coordination, and the finger and manual dexterity to manipulate electronic hand tools within confined work spaces.

Applicants for the electronics mechanic program should have a genuine interest in scientific and technical subjects, deriving satisfaction from the repair of electronic and mechanical devices, and working with machines and machine processes and techniques.

Workers in the field perform such duties as diagnosing equipment failure and maintaining precision equipment.

Trainees selected for this program should have completed satisfactorily at least one high school algebra course. Persons having additional mathematics training should be given preference in the selection process.

The abstract nature of electrical phenomena requires intense concentration at some stages of the training program, and only those persons with well-defined interests are likely to make satisfactory progress.

The U.S. Employment Service General Aptitude Test Battery B–359 for Electronics Mechanic also serves to assist in the selection of trainees.

Teacher Qualifications

An instructor for this program must have experience as an electronics mechanic and, preferably, should have experience as a supervisor of electronics mechanics.

If the person selected for this teaching assignment has no teaching experience, he should become familiar with the fundamental principles of lesson planning and presentation.

Suggestions for the Organization of Instruction

The total course presented in this training guide is intended to develop a marketable skill and to orient the trainee in the broad field of electronics.

The shop as well as the classroom instruction should be supplemented, where possible, by visual aids, models, and field trips. This is especially true when it is not possible to obtain certain special purpose equipment. Where this is the case, visits to industries may be required to provide the students with at least an introduction to certain elements of the instruction which cannot be treated adequately in the training facility.

The allocation of hours to each unit of instruction serves to indicate the relative emphasis to be placed on these units. Changes in this distribution of time may be necessary, depending on the ability and background of the group in training. Also, the ratio of classroom time to shop practice may need to be redistributed. While this training guide was designed for a class of 20 persons, the ideal student–teacher ratio in the laboratory would be about 10 to 1 since a great deal of individual instruction is required.

The development of any course outline involves some arbitrary choices regarding the topics to be included and the amount of time to be spent on each topic. Consequently, the contents of this guide should not be taken to be, in any sense, rigid, since some flexibility is called for in fitting the guide to local situations. The hours indicated provide about 20 percent of the time for "related material" and about 80 percent for electronic and electrical material. Within the electrical and electronic sections, about 60 percent of the time is devoted to shop experience while about 40 percent is used for classroom instruction.

Within the outline, mathematics is treated as a separate block. It is suggested, however, that this subject might be more effectively presented if it were integrated into the electrical sections as needed.

In the outline, the related material is scheduled for one hour per day so that the trainee will not be discouraged by lengthy discussions which are not directly related to the specialized subject.

It is felt that the above-stated proportions, coupled with the distribution of related material, will provide a well-rounded and effective program without sacrificing trainee interest.

Course Units

Unit I

MATHEMATICS

Training Time

Classroom, 135 hours

Objectives

To provide selected skills in mathematics.

Unit Outline

A. Arithmetic
   1. Common and decimal fractions
   2. Square roots
   3. Powers of ten

B. Algebra
   1. General numbers
   2. Addition, subtraction, multiplication, and division
   3. Equations
   4. Factoring
   5. Graphs
   6. Simultaneous equations
   7. Exponents and radicals
   8. Angles
   9. Trigonometric function
   10. Solutions of right triangles

C. Slide rule
   1. Multiplication
   2. Division
   3. Square and square root
   4. Cube and cube root
   5. Logarithms
   6. Power of *e*

D. Trigonometry
   1. Logarithms
   2. Practical applications
   3. Reduction formulas
   4. Graphic representation

Reference

Cooke. *Basic Mathematics for Electronics.*

Unit II

DIRECT CURRENT ELECTRICITY

Training Time

Classroom, 60 hours; shop, 85 hours

Objectives

To develop an understanding of basic electrical theory and the use of testing equipment.

Unit Outline

A. Introduction to electron behavior
B. Use, care, and calibration of basic instruments
   1. Basic meter circuits
   2. Multimeter
C. Ohm's and Kirchoff's Laws
D. Series, parallel, and combination circuits
E. Resistance networks

Suggested Shop Exercises

Exercises which require the use of the multimeter in making electrical measurements
Experiments which verify electrical principles
Application of Ohm's and Kirchoff's Laws

Reference

Gillie. *Electrical Principles of Electronics.*

Unit III

ELECTRONIC SHOP TOOLS

Training Time

Classroom, 22 hours; shop, 59 hours

Objectives

To provide skill in the use, care, and maintenance of hand and power tools.

Unit Outline

A. Hand tools
   1. Correct use of basic tools
      a. Squares
      b. Files
      c. Hacksaws
      d. Punches

2. Care and storage of tools

B. Soldering
   1. Care of soldering tools
   2. Preparing wire for soldering
   3. Correct use of soldering tools
   4. Fasteners
   5. Cables

C. Power tools
   1. Use of cutting machines
   2. Use of power drills
   3. Use of bending tools

Suggested Shop Exercises

Use of basic metal working hand tools to construct chassis
Use of soldering irons to make various types of electrical connections
Layout and construction of sheet metal chassis
Use of common power tools

Unit IV

MAGNETICS

Training Time

Classroom, 40 hours; shop, 20 hours

Objectives

To provide an understanding of magnetism and magnetic circuits.

Unit Outline

A. Introduction to magnetics
   1. Types of magnets
      a. Natural
      b. Artificial
         (1) Bar
         (2) Horseshoe
   2. Magnetic poles
      a. Weber's theory
      b. Attraction and repulsion
   3. Magnetic force
   4. Magnetic fields
      a. Characteristics
      b. Lines of force

B. Electromagnetism
   1. Left hand rule
   2. Magnetic fields
      a. Around single conductor
      b. Around two conductors
      c. Around a single loop of wire
      d. Around a coil of wire

C. Simple magnetic circuits

D. Series and parallel magnetic circuits

E. Simple motors and generators
   1. Generator action
   2. Left hand rule for generators
   3. Basic DC generator
   4. Basic DC Motor
   5. Right hand rule for motors

Suggested Shop Exercises

Experiments investigating magnetic fields around permanent magnetics
Plotting of magnetization curves of iron samples

Unit V

COMMUNICATIONS, WRITING

Training Time

Classroom, 30 hours

Objectives

To develop selected skills in written communications

Unit Outline

A. Business letters
   1. Styles
   2. Heading
   3. Body
      a. Grammar
      b. Punctuation
      c. Spelling
   4. Complimentary close

B. Keeping records of work
   1. File system
   2. Cards
   3. Time
   4. Production

C. Technical report writing
   1. Style
   2. Terms
   3. Content

References

Blumenthal. *English 3200, A Programmed Course in Grammar and Usage.*
Parkhurst. *English for Business.*

Unit VI

ALTERNATING CURRENT ELECTRICITY

Training Time

Classroom, 95 hours; shop, 130 hours

Objectives

To develop an understanding of alternating current and provide skills in the use of selected testing equipment.

Unit Outline

A. Introduction to the sinewave
B. Oscillators and signal generators
C. Oscilloscope
D. Characteristics of inductors
E. Characteristics of capacitors
F. Series R–L, R–C, and R–L–C circuits
G. Parallel R–L, R–C, and R–L–C circuits
H. Applications of R–L–C circuits
I. Bridge circuits, instruments
J. Wattmeters
K. Instrument calibrations
L. Transformers

Suggested Shop Exercises

Reactance, impedance, and phase shift determinations
Resonance determinations
Use, care, and calibration of oscilloscope and wattmeters

References

Carroll. *Electron Devices and Circuits.*
Gillie. *Electrical Principles of Electronics.*
Gillie. *Principles of Electron Devices.*

Unit VII

ELECTRONIC DEVICES

Training Time

Classroom, 45 hours; shop, 60 hours

Objectives

To provide an understanding of vacuum, gaseous, and solidstate devices.

Unit Outline

A. Vacuum tubes
   1. Diodes
   2. Triodes
   3. Tetrodes
   4. Pentodes
   5. Special purpose tubes
B. Gaseous tubes
C. Solidstate devices
   1. Diodes
   2. Transistors
   3. Special purpose semiconductors

Suggested Shop Exercises

Exercises which determine various types of vacuum and gaseous tube characteristics
Exercises which determine characteristics of various types of solidstate devices

References

Carroll. *Electron Devices and Circuits.*
Fitchen. *Transistor Circuit Analysis and Design.*
Geppert. *Basic Electron Tubes.*
Gillie. *Principles of Electron Devices.*

Unit VIII

POWER SUPPLY

Training Time

Classroom, 30 hours; shop, 50 hours

Objectives

To develop skills in the construction and testing of common power supply circuits.

Unit Outline

A. Half-wave rectifiers
   1. Principles
   2. Function
B. Full-wave rectifiers
   1. Principles
   2. Function
C. Crystal rectifiers
   1. Principles
   2. Function
D. Voltage multiplier
   1. Principles
   2. Function

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E. Filters
   1. Principles
   2. Function
F. Voltage regulators
   1. Principles
   2. Function

Suggested Shop Exercises

Construction and testing of vacuum tube power supplies
Construction and testing of gaseous tube power supplies
Construction and testing of semiconductor power supplies

References

Carroll. *Electron Devices and Circuits*
Cutler. *Semiconductor Circuit Analysis.*

Unit IX

SKETCHING AND BLUEPRINT READING

Training Time

Classroom, 17 hours; shop 60 hours

Objectives

To develop selected skills in sketching and blueprint reading.

Unit Outline

A. Sketching
   1. Straight lines and circles
   2. Shading and perspective
   3. Proper dimensioning
   4. Use and care of drawing equipment
B. Projection
   1. Isometric
   2. Oblique
   3. Perspective
C. Circuit diagrams
   1. Symbols
   2. Color coding
   3. Schematics
D. Duplicating processes
   1. Ozalid
   2. Blueprint
   3. Xerox
   4. Others

Suggested Laboratory Exercises

Freehand sketching practice
Projection exercises
Problems of circuit diagrams

Reference

Shires, *Electronic Drafting.*

Unit X

AMPLIFIERS

Training Time

Classroom, 55 hours; shop, 90 hours

Objectives

To develop an understanding of the fundamentals of amplifiers and provide exercises to determine basic amplifier characteristics.

Unit Outline

A. Untuned voltage amplifiers
B. Tuned voltage amplifiers
C. Power amplifiers
D. Coupling networks
E. Cascaded amplifiers
F. Feedback in amplifier circuits

Suggested Shop Exercises

Determine basic tube-type amplifier characteristics
Problems in basic transistor-type amplifier characteristics

References

Carroll, *Electron Devices and Circuits.*
Fitchen, *Transistor Circuit Analysis and Design.*

Unit XI

OSCILLATORS

Training Time

Classroom, 40 hours; shop, 65 hours

Objectives

To provide an understanding of oscillator principles and develop skills in the construction, adjustment, and testing of selected oscillators.

Unit Outline

A. Crystal oscillators
   1. Basic operation
   2. Conventional circuits
B. R–C oscillators
   1. Basic operation
   2. Phase-shift
   3. Conventional circuits
   4. Special purpose
C. L–C oscillators
   1. Basic operation
   2. Phase-shift
   3. Conventional circuits
   4. Special purpose
D. Oscillator stability
E. Oscillator applications

Suggested Shop Exercises

Exercise emphasizing oscillator principles
Construct, adjust, and test selected oscillators

Reference

Reyner and Reyner. *Radio Communications.*

Unit XII

WAVESHAPING

Training Time

Classroom, 41 hours; shop, 66 hours

Objectives

To develop an understanding of the principles of various waveshaping circuits and provide experience in construction, adjustment, and testing of such circuits.

Unit Outline

A. Clippers and clampers
   1. Diode limiters
   2. Double-diode limiters
   3. Triode limiters
   4. Diode clamping
B. Differentiators and integrators
   1. Basic operation
   2. R–C differentiator
   3. R–L differentiator
   4. Integration
   5. Differentiated and integrated voltage waveshapes
C. Multivibrators
   1. Free-running type
   2. One-shot type
   3. Flip-flop type
D. Blocking oscillators
   1. Free-running single-swing blocking oscillator
   2. Triggered single-swing blocking oscillator
   3. Self-pulsing blocking oscillator
E. Ramp generators
   1. Gas-tube sawtooth-wave generator
   2. Vacuum-tube sweep generator

Suggested Shop Exercises

Exercises in the operation of various waveshaping circuits
Construct, adjust, and test various waveshaping circuits

References

Carroll. *Electron Devices and Circuits.*
Fitchen. *Transistor Circuit Analysis and Design.*

Unit XIII

ELECTRONIC CONTROLS

Training Time

Classroom, 45 hours; shop, 65 hours

Objectives

To develop skills in the examination and testing of both tube and solidstate control circuits.

Unit Outline

A. Switching circuits
B. Thyratron and SCR motor controls
C. Time delay circuits
D. Saturable reactors
   1. Fundamental concepts
   2. Saturable reactor circuit analysis
E. Photo electric controls
F. Sequential operations
G. Error correction devices

Suggested Shop Exercises

Examining, testing, and troubleshooting of tube control circuits
Examining, testing, and troubleshooting of solidstate control circuits

References

Carroll. *Electron Devices and Circuits.*
Prensky. *Electronic Instrumentation.*

Unit XIV

COMMUNICATIONS, TRANSMITTERS, AND RECEIVERS

Training Time

Classroom, 45 hours; shop, 50 hours

Objectives

To acquaint students with industrial applications of common communication circuits.

Unit Outline

A. AM transmitters
   1. AM principles
   2. AM circuits
   3. AM methods
   4. Tuning procedures
   5. Measurements
   6. Troubleshooting procedures

B. AM receivers
   1. Basic radio receiver
   2. TRF receiver
   3. Superhetrodyne receiver
   4. Receiver alignment procedures
   5. Troubleshooting procedures

C. FM transmitters and receivers
   1. Modulation principles
   2. Modulator types
   3. Functional analysis

D. Multiplexing

E. Television receivers
   1. Functional analysis
   2. System principles

F. Antennas and transmission lines
   1. Antenna fundamentals
   2. Transmission line theory
   3. Types of antennas

Suggested Shop Exercises

Troubleshooting and aligning of tube communications circuits
Troubleshooting and aligning of solidstate communications circuits

Reference

Reyner and Reyner. *Radio Communications.*

Teaching the Course

Planning the Lesson

The best guide or lesson plan is, of course, one that has been prepared by the instructor, based on his experience and manner of teaching. Although instructors differ in their ways of organizing and coordinating important parts of their presentations, they agree that the purpose of a lesson is effective and meaningful classroom instruction.

Written plans may be brief, but before class starts the good teacher will establish:

The goals or objectives of the lesson—the kind of learning desired
The outline and suggested time schedule for the lesson, including:
An interesting approach to the lesson, capturing the interest of the trainees, and directing their attention to its goals or objectives
Activities which will involve the trainees in discovering new facts and principles, solving realistic problems, or practicing skills
A way to summarize the lesson—to help trainees arrive at some valid conclusions and/or to evaluate the extent to which lesson goals have been achieved
The subject matter content—the facts and principles or main ideas to be brought out in the lesson
The instructional materials and references to be used

Training Facility Considerations

The equipment chosen for any electronics program will reflect the experience of the person compiling the list. That is to say, instructors will disagree as to which instruments are best suited to a particular job and which equipment more nearly represents industrial requirements. Consequently, the following lists of materials should be viewed as constituting a typical shop setup and should not be considered the only possible choices.

Many of the items in the lists of materials will normally be available in an existing electronics department. Therefore, it is essential that a specialist survey the materials on hand before purchasing equipment for this program.

The prices are included to indicate the approximate quality of each item; and, again, considerable flexibility must be recommended. Additional specifications will be required, in most cases, before purchases can be made.

The shop layout shown was chosen for its flexibility and simplicity. Virtually any well-lighted room (50 foot-candles of illumination) of from 2,200 to 2,400 square feet will be adequate if the workbenches are provided with 115-volt, 15-ampere, 60-cycle, alternating current outlets. No additional voltages will be required if the recommended power supplies are provided, as shown on the equipment list.

Bench tops and floors should be of an insulating material. Experience has shown that tempered hard board is inexpensive for table tops and is reasonably easy to replace. Concrete floors should be covered with an insulating material such as vinyl or cork tile.

It is highly recommended that each student have an assigned work station. This will permit the entire class to be involved in a shop exercise simultaneously and will permit the students' work to remain undisturbed between shop sessions. When possible, the classroom instruction, sketching, and blueprint reading should be conducted in a separate room. The presence of shop equipment tends to distract the trainee and thereby reduces the effectiveness of the classroom discussion.

Criteria for Evaluating Trainee Readiness for Employment

The primary criterion used for determining whether the trainee is ready for employment as an electronics mechanic will be his technical performance. However, some understanding of and insight into the business and work relationships he will encounter are of such importance that every attempt must be made to evaluate trainee progress in this area as well.

Various evaluative devices such as tests, interviews, etc., enable the teacher and the trainee to estimate the growth of the trainee. The following personal qualities and characteristics should be developed or strengthened during the training program:

Courtesy, friendliness, and tact in dealing with supervisors, fellow workers, and the general public
Acceptable appearance—good grooming, cleanliness, and neatness in dress, sensible choice of clothing
Acceptable attitudes—calmness in disorganized situations, cooperativeness, willingness to work with others
Understanding of the role of the electronics mechanic
Ability to understand and follow through on instructions or directions
Ability to work with minimum immediate supervision
Ability to keep repair facilities clean and orderly
Ability to use and properly maintain required tools
Ability to develop and follow a work plan or schedule
Observance of basic safety precautions.

Textbooks and References

Blumenthal, Joseph C. *English 3200. A Programmed Course in Grammar and Usage*. New York: Harcourt, Brace and World, Inc., 1962.

Carroll, John M. *Electron Devices and Circuits*. New York: McGraw-Hill Book Co., Inc., 1962.

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Geppert, Donovan V. *Basic Electron Tubes*. New York: McGraw-Hill Book Co., Inc., 1962.

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Parkhurst, Charles Chandler. *English for Business*. 4th ed. Englewood Cliffs, N.J.: Prentice-Hall, 1963.

Prensky, Sol D. *Electronic Instrumentation*. Englewood Cliffs, N.J.: Prentice-Hall, 1963.

Reyner, J. H. and P. J. Reyner. *Radio Communications*. London: Sir Isaac Pitman and Sons, Ltd., 1962.

Shires, George. *Electronic Drafting*. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1962.

Films

A IS FOR ATOM
16 mm., sound, 15 minutes
U.S. Atomic Energy Commission, 1953

BASIC ELECTRICITY—HOW MAGNETS PRODUCE ELECTRICITY
(MN8016B) 16 mm., sound, 3 minutes
U.S. Department of the Navy, 1954

ELECTRONICS IN AUTOMATION
16 mm., sound, 22 minutes
DeVry, 1957

PRINTED CIRCUIT STORY, THE
16 mm., sound, 25 minutes
Bray, 1962

SEMICONDUCTORS
(2 films) 16 mm., sound, 43 minutes
Bray, 1960

TRANSISTORS, THE
16 mm., sound, 14 minutes
Bell Systems, 1958

These films, as well as many others, may be found in the *Educator's Guide to Free Films*.

Appendixes

Appendix A

SUGGESTED LIST OF MACHINES

Quantity	*Description*	*Estimated total price**
1	Drill press, ½″ chuck	$307.00
1	Grinder, 1 hp, 2″ wide wheel, double arbor	225.00

*Prices quoted were obtained in 1966.

Appendix B

SUGGESTED LIST OF TOOLS

Quantity	*Description*	*Estimated total price**
20	Drawing sets, complete as follows: 5½″ compass, 3″ extension bar, interchangeable pen, 4″ combination spring bow pen and pencil, 4″ spring bow divider, 4½″ ruling pen	$330.00
20	Drawing sets complete as follows: 48″ T-square, triangular architect's scale, triangle 30° x 60°, 8″ triangle 45° x 45°, 6″ French curve, 8″ pencil pointer, pencils, H, 3H, 6H, eraser, protractor, drafting tape, brush	150.00
2	Drills, portable, electric, ¼″ chuck	85.00
10	Pliers, needle nose, 2″	27.00
10	Pliers, diagonal, wire cutter, 1″	27.00
10	Pliers, gas, 2″	27.00
10	Squares, combination	35.00
10	Micrometers, 1″	150.00
10	Screwdrivers 6″, .041″ x 5/16″ tip	17.00
10	Files, smooth mill, 10″	15.00
2	Hacksaw frames, adjustable, 10″ to 12″	12.00
10	Screwdrivers, 6″ phillips, #4–9	14.00
2	Wrenches, adjustable, 8″	4.00
1	Drill, twist, set, 1/64″ to ½″, 32 drills	28.00
1	Punch, chassis, set, ½″ to 1½″, 7 punches	10.00
10	Soldering irons, 175-watt	175.00
10	Soldering irons, 50-watt	80.00

*Prices quoted were obtained in 1966.

Appendix C

SUGGESTED LIST OF EQUIPMENT

Quantity	*Description*	*Estimated total price**
10	Cabinets, metal storage, 3′ wide, 2′ deep, 6′ high	$300.00
10	Tables, suitable for drawing and laboratory work, 3′ x 8′ top, 36″ high	1,600.00
2	Tables, suitable for general work, 3′ x 8′ top, 36″ high	320.00
20	Stools, steel frame with 13″ diameter wood seat, 27″ high	140.00
20	Drawing boards, steel edge	240.00
1	Demonstration slide rule, 6′	50.00
2	Vises, solid base, 3½″ jaw, 4″ opening	90.00
10	Oscilloscopes, 5″ screen, horizontal and vertical inputs, internal sweep, gen. provision for external sync., internal vertical calibrator	4,700.00
10	Vacuum tube voltmeters, bandwidth 0–1 mc, ranges: DC, 1–5 volt to 1,000 volts AC, 1–5 volt to 1,000 volts OHMS, R x 1 to R x 1 meg	480.00
10	Generators, audio, 0–20 volt output, 10 cps to 100 kc sinewave	2,800.00
10	Generators, square wave, 0–20 volt putput, rise time less than 10 us, 10 cps–50 kc	4,700.00
10	Variacs, 0–130 vrms, 60 cps, 1 KVA	1,200.00
10	Multimeters, sensitivity 100,000 ohms per volt DC, 5,000 ohms per volt AC, Ranges: DC volts, 1–5 to 1,500 AC volts, 1–5 to 1,500 DC amps, 50 a to 1.5 a Ohms, R x 1 to R x 1 meg	790.00
10	R.F. signal generators, 100 kc to 100 mc, sinosoidal output, 0–1 vrms	950.00
10	DC power supplies, 0–500 volts, 0–100 ma regulation less than ±2%	780.00
20	DC power supplies, 0–30 volts, 0–300 ma	380.00
10	Wattmeters, dynamometer type, 0–100 watts	790.00
10	Resistance decades, .1 ohm to 999K ohms	290.00
10	Ammeters, range: 1 to 1,000 ma, AC	250.00
10	Ammeters, range: 1 to 1,000 ma, DC	220.00
1	Tube checker, mutual conductance type	480.00
1	Wheatstone bridge, audio frequency	480.00
1	Transistor curve tracer, 5″ display	1,200.00
1	Projector, overhead	265.00
1	Table, instructor's demonstration, mounted on rubber wheels with storage compartments below	200.00

*Prices quoted were obtained in 1966.

Appendix D

SUGGESTED LIST OF EXPENDABLE MATERIALS

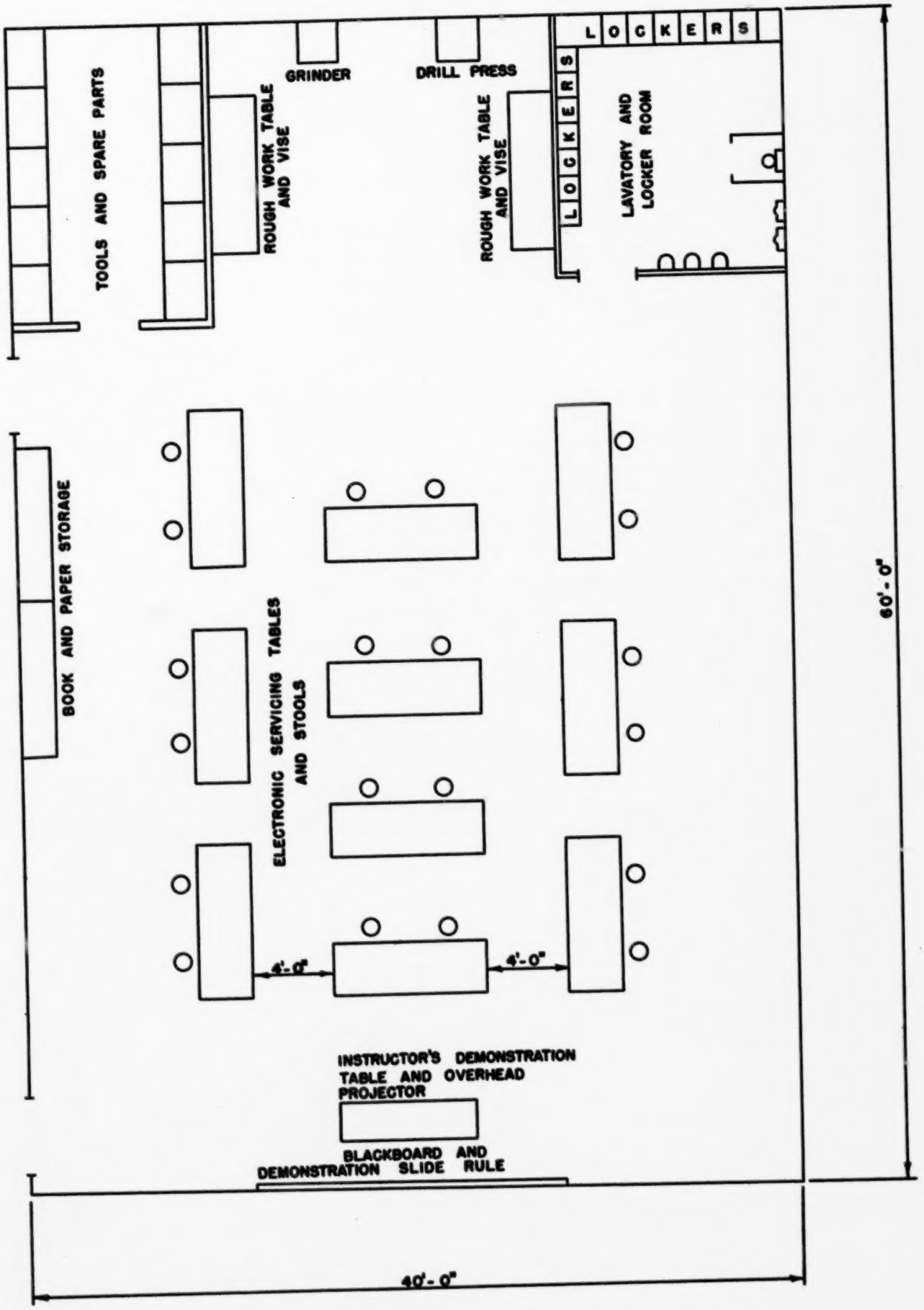
Quantity	*Description*	*Estimated total price**
10	Resistor assortments, 2 watts, 34 values from 47 ohms to 10 meg ohms	$75.00
10	10-ohm, 100-watt resistors	16.00
10	25-ohm, 100-watt resistors	16.00
10	50-ohm, 100-watt resistors	16.00
10	75-ohm, 100-watt resistors	16.00
10	100-ohm, 100-watt resistors	16.00
10	Capacitor assortments, disc ceramic, 500 WVDC, 15 values from 10 mmfd to 10,000 mmfd	38.00
10	Capacitor assortments, paper, 600 WVDC, 10 values .01 mfd to 1 mfd	50.00
10	Capacitor assortments, electrolytic, 10 WVDC to 450 VDC, 10 values, 10 mfd to 100 mfd	80.00
10	R.F. choke assortments, Pi wound, minimum Q, 15, 10 values, 10 uh to 1,000 uh.	50.00
10	1 henry audio chokes, Q, about 10 at 60 cps	100.00
10	DPDT, 110-volt, 60-cycle relays	50.00
10	DPDT, 10 ma pullin, plate relays	50.00
10	DPDT, toggle switches	10.00
16	Potentiometer assortments, 1 watt, 15 values, 500 ohms to 5 meg ohms	150.00
10	Power rheostats, 100 watts, 100 ohms	70.00
10	4-pin tube sockets	5.00
10	8-pin octal tube sockets	5.00
10	7-pin miniature tube sockets	5.00
10	9-pin miniature tube sockets	5.00
10	12-pin CRT sockets	5.00
100	Clipleads, 18″ with alligator clips	40.00
1	Piece galvanized sheet steel, 22 gage, 36″ x 96″	60.00
10 gross	Bolts and nuts, 6–32 x ½ and 8–32 x ½	10.00
10	Hookup wire assortments, 8 colors, #20	50.00
10 lb	Solder, 60–40, multiresin core	15.00
10	Input IF transformers, 455KC, 10K–600 ohms	20.00
10	Output IF transformers, 455KC, 10K–1,000 ohms	20.00
10	Universal input IF transformers, 455KC	20.00
10	Universal output IF transformers, 455KC	20.00
10	60-cycle, 1:1 transformers, 1 KVA	100.00
10	6SN7 dual triodes	13.00
10	6AQ5 beampower tubes	11.00
10	1P39 vacuum photo tubes	14.00
10	1P40 gas photo tubes	17.00
10	3JP1 cathode ray tubes	150.00
10	6X4 dual diodes	8.50
10	816 gas diodes	15.00
10	6AL5 dual diodes	10.00
10	3C23 thyratrons	60.00
10	PNP audio transistors	20.00

Quantity	*Description*	*Estimated total price**
10	PNP audio transistors	20. 00
10	PNP RF transistors	20. 00
10	NPN RF transistors	20. 00
20	Silicon diodes	20. 00
10	Zener diodes (1 watt)	20. 00
10	PNP power transistors	40. 00
10	Tunnel diodes	40. 00
10	Silicon controlled rectifiers	70. 00
10	Photo transistors	40. 00
	Allowance for slides and transparencies	200. 00

**Prices quoted were obtained in 1966.*

Appendix E

SUGGESTED TRAINING FACILITY



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